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Mobility indicators put to test – German strategy for sustainable development needs to be revised

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Abstract

Similar to other countries, Germany uses a national indicator set to monitor the progress of its sustainability strategy. As transport is one of the priority areas of a more sustainable development, this indicator system also includes a number of transport related indicators. After 10 years of using these transport indicators, the German Environment Agency contracted a scientific project to review their suitability. This paper describes the methodological approach taken within the project and the main results. A special consideration is thereby given to the commonly used modal split and transport intensity indicators. An assessment of the indicator practice within other European member states expands the national analysis and shows similarities and disparities in the indicator systems within Europe.

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Keywords: transport indicators; sustainability; transport intensity; decoupling; modal split; indicator assessment

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1. Introduction

Indicators have become an important and widely used instrument to evaluate progress towards a more sustainable development (SD). SD indicators are used for varying purposes and from different actors. At the national level, one of their most prominent uses is the evaluation of the progress of the respective national SD strategy. However, the coverage of such systems and the number and definition of the included indicators vary greatly.

Although most countries frequently revise their SD indicator system, few scientific studies critically discuss the suitability of concrete indicators or indicator sets used in practice (see e. g. Leukhardt and Allen (2013); Steurer and Hametner (2013) for some exceptions). For the case of the transport indicators used in the German SD indicator system, this paper aims to conduct such a review. It presents the methodology used and the main results of the review. Finally, the state of practice in other European countries is assessed, before a summary of the lessons learnt and recommendations for the further enhancement of transport indicators are given.

2. Evaluating the suitability of transport indicators – the case of the German Sustainability Strategy

2.1. Introduction to the German Sustainability Strategy and its SD indicator system

Germany implemented its national strategy for Sustainable Development in 2002 (The Federal Government (2002)). This strategy "Perspectives for Germany" sets the guiding principles and management rules for the national sustainability policy. It also outlines the framework for monitoring progress towards a more sustainable development. A main element of the monitoring framework is a so-called "Kernindikatorensystem" (core indicator system) which is supposed to spotlight areas with a major need for change (The Federal Government (2012)).

The core indicator system of the German SD strategy is a rather slim indicator system, which at present consists of 21 indicators (38 indicators when counting sub-indicators) in the four priority areas "Intergenerational Justice", "Quality of Life", "Social Cohesion" and "International Responsibility". Indicator results are reported every second year within a SD indicator report published by the Federal Statistical Office (Statistisches Bundesamt (2014)). Every fourth year, the Federal Government publishes a progress report with an overview of federal SD activities and engagement. The compilation of this report is also used to review and slightly adapt the indicator system, e. g. in cases in which the Federal Government agreed upon new political goals (The Federal Government (2012)).

The core indicator system includes a number of indicators which directly or indirectly refer to the SD impacts of the transport sector. As Table 1 shows, the indicator 11 "mobility" directly addresses characteristics of the transport system. Other indicators e. g. in the area of energy consumption, climate change and air pollutant emissions are highly influenced by the magnitude of transport activities even if they only picture the combined impact of all sectors' activities without stating separate figures for transport.

Most indicators have been in use since the implementation of the SD strategy in 2002. By now, it has become visible that some indicators might not be as unambiguous as intended. In addition, Table 1 shows that most of the target values originally set for the indicators will not be reached, at least without additional massive effort. Besides, most indicators have been formulated with a target year of 2020 or even earlier.

Hence, the Federal Government initiated an extensive process to revise the SD strategy and its indicators. This process includes the consideration of the predefined UN Sustainable Development Goals (SDGs) and the realization of a public participation. The revised SD strategy with indicator targets up to 2030 shall be set up until autumn 2016. The project described here was undertaken on behalf of the German Environment Agency to support this process.

2.2. Methodological approach

Within the scientific literature, innumerable proposals for the development of transport-specific SD indicator systems exist (see e. g. Haghshenas and Vaziri (2012); Joumard and Gudmundsson (2010); Nicolas et al. (2003); Sanna Ahvenharju et al. (2004)). However, in contrast to these systems, the German national SD indicator system does not intend to present all sustainability impacts of the transport sector in a detailed manner. The included indicators should therefore be chosen with the aim to primarily spotlight the most important SD issues in the transport sector.

For this reason, we decided to apply a combined top-down/bottom-up approach for the identification of the most relevant sustainability issues in transport. This approach has been elaborated originally within the research project "Global Sustainable Development – Perspectives for Germany." (Hartmuth (2004); Kopfmüller (2001)) and is based on a four step indicator selection process (see Figure 1).

Table 1. Mobility indicators in the German national strategy for sustainable development (The Federal Government (2012)).

No.	Indicator name	Target year(s)	Indicator development (up to 2012)
Indicators directly referring to transport			
11a	Intensity of goods transport (domestic goods transport performance in tonne-km/GDP in €)	2020	Right direction, but a gap of more than 20% to the target will remain for the target year if the trend continues unchanged
11b	Intensity of passenger transport (transport performance in passenger-km/GDP in €)	2020	Right direction, but a gap of more than 20% to the target will remain for the target year if the trend continues unchanged
11c	Share of rail transport in goods transport performance	2015	Wrong direction, distance to the goal will become even greater if trend continues unchanged
11d	Share of inland freight water transport in goods transport performance	2015	Wrong direction, distance to the goal will become even greater if trend continues unchanged
Indicators indirectly referring to transport (cross-sectoral)			
1b	Primary energy consumption	2020, 2050	Right direction, but a gap of more than 20% to the target will remain for the target year if the trend continues unchanged
2	Greenhouse gas emissions	2010, 2020, 2050	The target will be reached if the trend continues unchanged
3a	Share of renewable energy sources in final energy consumption	2020, 2050	The target will be reached if the trend continues unchanged
4	Built-up area and transport infrastructure expansion	2020	Right direction, but a gap of 5-20% to the target will remain for the target year if the trend continues unchanged
13	Air pollution	2010	Right direction, but a gap of 5-20% to the target remained
14	Premature mortality	2015	Right direction, but a gap of 5-20% to the target will remain for the target year if the trend continues unchanged

In the first step, the general principle of sustainability – "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations (1987)) – has been differentiated. The aim was to deduce more precise rules for a sustainable transport system from the rather general concept of sustainability. Those rules could then be used as a minimum standard for a sustainable transport development which should be reflected within the national SD indicator set.

In the second step, a revision of national key strategic papers, policy documents and position papers was conducted to identify the transport developments considered to be the most important and pressing ones. This step resulted in a compilation of transport-related problem areas which should be addressed according to the points of view of national policy makers.

Within the third step, the transport-related problem areas have been matched with the minimum standard for a sustainable transport system identified in the first step. This allowed us to embed the current transport problems in the context of a sustainable transport development and at the same time to reduce the amount of aspects which needed to be considered for the evaluation of the national SD indicator system to the truly relevant ones.

Finally, the adequateness of the indicators has been assessed in the fourth step. For this purpose, the currently used and potential other indicators have been evaluated. The results as well as the developed indicator proposals have been discussed with scientific experts as well as with representatives of the involved federal ministries. The main results of this approach will be presented in the next section.

2.3. Overview of the main results

The table in Appendix A (column 2) shows the mentioned "minimum standards" for a sustainable transport system, which have been derived from the central definition of sustainable mobility originally formulated by the

"Centre for Sustainable Transportation" (Cormier and Gilbert (2005)). It also contains a first grouping of these standards in priority areas of a sustainable transport system (column 3). Column 4 of this table then contains an overview of the most pressing transport problems and how they have been matched with the identified sustainable transport priority areas.

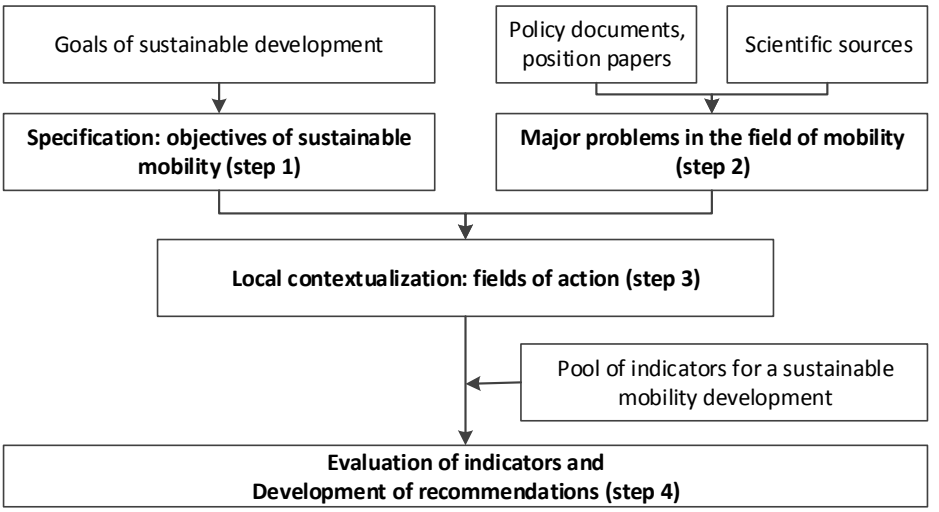

Fig 1. Schematic description of the indicator selection process (source: author, based on Hartmuth (2004)).

From the normative minimum standards of a sustainable transportation system, we have been able to identify eleven priority areas: 1. Climate change, 2. Energy consumption, 3. Decoupling, 4. Land use and fragmentation, 5. Financial sustainability, 6. Air quality, 7. Noise, 8. Traffic safety, 9. Guaranteeing mobility/access, as well as 10. Participation and 11. International responsibility.

However, only nine of these priority areas also relate to transport problems playing a major role in the analyzed policy documents. Participation in the transport planning process and taking international responsibility played a minor role compared to the other problems named. For this reason, we did not take them into account within the following indicator analysis.

For the indicator analysis, we matched the identified priority areas with the indicators used in the German core indicator system and evaluated the suitability of the chosen indicators according to the assessment criteria "scientific grounding", "availability of data" as well as "comprehensibility" and "political relevance". Table 2 shows an overview of the results including the shortcomings of the indicators used.

Then it comes to the construction of the individual indicators, most indicators can be classified as sufficiently sound and reliable. They could be improved by minor revisions, e. g. in the graphic display or an update of the relevant sustainability goals. Nonetheless, their fundamental design allows an adequate monitoring of SD.

However, this is not the case for the indicators directly addressing the transport system. The development of the transport intensity indicators (11a-b) and modal split indicators (11c-d) does not allow any direct conclusions concerning the sustainability of the transport system. The shortcomings of these central indicators will be discussed in more detail in the next section.

To sum up the analysis, it can be concluded that the core indicator system addresses most, but not all priority areas of a sustainable transport development. Especially the social and economic dimensions of transport are not covered in the current system. Environmental sustainability is covered quite well with the exception of a lack of indicators addressing the quality of life and health impacts of noise.

A last general point needs to be made concerning the scope of the indicators used. Since the core indicator system is a national system, all indicators are based on the domestic principle. This means that the sustainability impact in question is evaluated considering all relevant activities within the territory of the Federal Republic of Germany.

Table 2. Matching of indicators to sustainable transport priority areas and shortcomings of the indicators used in the German SD indicator system.

Priority Area	Current indicator in German SD indicator system	Shortcomings
1. Climate change	Indicator 2 „Greenhouse gas emissions“	No differentiation by sector, residential principle is not applied
2. Energy consumption	Indicator 1 „Primary energy consumption“	No differentiation by sector, residential principle is not applied
	Indicator 3a “Share of renewable energy sources in final energy consumption“	No differentiation by sector, development in absolute terms is not depicted
3. Decoupling	Indicator 11a „Intensity of goods transport“	No reflection of the underlying sustainability goals
	Indicator 11b „Intensity of passenger transport“	No reflection of the underlying sustainability goals
	Indicator 11c „Share of rail transport in goods transport performance“	No reflection of the underlying sustainability goals, development in absolute terms is not depicted
	Indicator 11d „Share of inland freight water transport in goods transport performance“	No reflection of the underlying sustainability goals, development in absolute terms is not depicted
4. Land use and fragmentation	Indicator 4 „Built-up area and transport infrastructure expansion“	Good representation of land use by sector, fragmentation could be depicted additionally
5. Financial sustainability	Indicator 7 „Gross fixed capital formation in relation to GDP“	Indicator does not allow conclusions concerning the maintenance state of infrastructure, nor does it address user financing
6. Air quality	Indicator 13 „Air pollution“	Development of particulate matter emissions is not monitored, update of target values and timeframe necessary, index of the overall development of air pollutant emissions does not consider that pollutants are of unequal importance
7. Noise	No indicator included	Indicator should be added
8. Traffic safety	Indicator 14 „Premature mortality“	Indicator does not differentiate mortality causes, indicator does not consider changes in morbidity
9. Guaranteeing mobility / access	No indicator included	Indicator should be added

The magnitude of impacts obtained with this accounting principle substantially deviates from results obtained with a consumer or resident based perspective. For the transport sector, this deviation is especially relevant when it comes to the energy consumption and climate change impact of transport activities. The current indicator practice neither includes residents’ transport activities abroad (e. g. international flights) nor the transport activities necessary to import or export raw materials and goods. However, these activities increasingly dominate the total impacts of transport, making it increasingly necessary to include them within a sound national SD monitoring.

2.4. The problem with transport intensity and modal split indicators

Indicators stating the modal distribution of the passenger or goods transport performance are commonly used to assess the development of the transport system. The same holds true for transport intensity indicators. However, as will be argued below, both indicators may rather conceal then highlight the development of the transport system.

A first important reason for that is that both indicators actually do not represent “true” SD goals. A sustainable transport system is one that serves the needs of the people (today and in future) and does not deplete natural resources. But modal split indicators do not allow for conclusions concerning the development of the environmental impacts caused by transport activities. As shown in the simple calculation example in Table 3, the same modal split development can generate less as well as more environmental damages. At the same time, it is possible that the modal split deteriorates while the environmental situation improves. Thus, modal split indicators alone are not meaningful regarding the actual aim of reducing the environmental impacts. They could be used as explanatory variables but they should not replace indicators monitoring the actual environmental impacts in absolute terms.

Table 3. Relationship between modal split indicators and the development of the environment (author: own source).

Case	Road	Rail	% Road	% Rail	Development Modal Split	Development Environment
Reference Case	300 tonne-km	300 tonne-km	50%	50%	Reference case	Reference case
Alternative 1	400 tonne-km	600 tonne-km	40%	60%	Improvement	Degradation
Alternative 2	200 tonne-km	300 tonne-km	40%	60%	Improvement	Improvement
Alternative 3	300 tonne-km	200 tonne-km	60%	40%	Deterioration	Improvement

The same argument holds true for transport intensity indicators. In theory, they are meant to measure "decoupling", meaning the decoupling of economic growth (something desirable within the logic of the concept) from the underlying unwanted transportation effort and environmental degradation. Indicators depicting the goods or passenger transport intensity are often calculated by dividing the goods or passenger transport performance (in passenger-km or tonne-km) by the GDP (in €). They are indicators of efficiency, admittedly something useful for SD. However, intensity indicators fail in practice due to a number of reasons.

Firstly, they most often concentrate on transportation performance and not on the underlying environmental damage. So, the same shortcomings apply as for modal split indicators.

Secondly, efficiency is only truly sustainable when it leads to less environmental pressure. However, rebound effects and economy of scales often diminish or even overcompensate savings due to efficiency gains (Gudmundsson and Höjer (1996); Jackson (2009); UNEP (2011)). This makes efficiency indicators less suitable for the assessment of SD, at least if they are not supported by indicators monitoring absolute environmental damages. Unfortunately, such indicators are often missing.

Finally, the indicator values are increasingly distorted due to the growing importance of international trade and division of labor. In Germany, export revenues represent a growing part of the GDP – they are fully covered by the transport intensity indicators.

Contrary to that, the transportation activities associated with the import and export of goods are not covered by the domestic transport performance statistics. In the year 1995, transport CO_2 emissions resulting from import and export accounted for 84 percent of the CO_2 emissions from the domestic goods transport. In 2005, the transport CO_2 emissions connected with the import and export of goods already exceeded the CO_2 emissions from domestic goods transport. (own calculation, based on Buyny et al. (2008)). Hence, the transport intensity indicators in the German national SD strategy are increasingly biased in a "positive way" meaning that in reality the development is far less positive as depicted. In the end, this makes them unsuitable for evaluating sustainable transport development.

3. Getting the bigger picture – an overview of the use of transport indicators in Europe

In the same way as Germany, most member states of the European Union developed national sustainability strategies and accompanying indicator systems. These indicator systems vary greatly both in focus and design, some consist of more than 100 indicators while other systems depict less than 50. Our review of these systems was conducted with the aim to get a more general picture on the member states' perception of sustainable transport development. Which are the sustainability transportation issues addressed by the member states? Is there something like a consistent perception of the sustainability problems of transport? Do member states use similar indicators for depicting SD in transport?

In order to gain information on these questions, we analyzed national indicator reports of the member states. Due to language barriers, we had to restrict ourselves to reports available in German, English, Dutch and Spanish. For each member state, we used the last published version identified in an extensive internet search. In some member states, information on the national SD strategy and the latest indicator reports were difficult to find, either due to language barriers or/and a less prominent placement within the web sites of the responsible ministries. In cases, we could not use original sources, we reviewed the information given within a secondary source comparing SD strategies within the European Union on a more general level: Eurostat (2007).

The table in Appendix B shows an overview of the transport-related topics covered by the national SD indicator systems. All countries used indicators addressing the topics climate change and energy use. However, not all of

them differentiated these indicators by sectors and thus stated transport energy use and emissions. In the same way, most countries addressed air pollution in their indicator system.

Despite their methodological weaknesses (see section 2.4), transport intensity and modal split indicators are the most commonly reported transport indicators. In the case of the modal split indicator, a possible reason could be that indicator results can easily be communicated to decision makers. From a methodological point of view, these indicators could be used as "contextual" indicators, at least if they have been supported with further indicators stating absolute environmental damages. The Austrian indicator "transport performance by mode" might serve as a good practice example for the depiction of modal split values. Besides the modal distribution the respective indicator shows the absolute development of the transport performance of the considered modes (Lebensministerium (2011)).

Some member states also try to address the weaknesses associated with the transport intensity indicators. While e. g. Germany depicts additional information in the indicator graph (absolute development of the GDP and transport performance, development of the energy efficiency in transport and the total energy consumption of transport) in order to further explain the development of the actual indicator, other member states improve the indicator with a more appropriate data base. The Czech sustainability indicator system might serve as an example, here, the GDP development has not been linked to the total domestic goods transport, but to the transport performance of Czech haulers inside, but also outside of the Czech territory. This might come closer to depicting a meaningful relationship; however the question remains whether decoupling itself is a meaningful SD target without relating it to absolute planetary boundaries.

Noise is addressed within some national SD indicator systems, here, subjective indicators are used as well as objective indicators based on the European Environmental Noise Mapping. Guaranteeing access seems to be an emerging topic addressed already by 11 of the 28 analyzed countries. This sustainability topic is characterized by a big variety of indicators. The chosen indicators range from the accessibility of public transport stations to distances travelled to schools and work and the connectivity of the cycling network. This variety reflects the ongoing scientific debate on the measurement of accessibility and more general the relationship between transport, social exclusion and well-being.

Besides the social dimension of a sustainable transport development, the economic dimension is also addressed by some indicator systems. The used indicators address as diverse topics as the generation of external costs, the amount of household expenditures used on mobility or the magnitude of investments in transport infrastructure. Similar to the social dimensions of transport, more research is necessary to develop suitable indicators for all relevant issues here.

4. Conclusions

As shown in the paper, a systematic review can be helpful to identify shortcomings and possible improvements of SD indicators. For the case of the transport indicators in the German indicator system, the environmental dimension (climate change, air pollution, land use and energy consumption) is reflected quite well. Contrary to that, the social and economic dimensions of a sustainable transport development are neglected in the current system. Here, more work is necessary to define suitable indicators.

Major improvements are possible by including a resident based perspective and by focusing on indicators referring directly to the absolute (environmental) impacts of transport. The modal split indicators are less suitable and should be used only as context indicators. As such, they can find a place within the national SD indicator system or subsequent sector-specific indicator systems. Transport intensity indicators show weaknesses due to a number of reasons and cannot be interpreted in a useful manner in most cases. Their suitability should also be discussed at the European level, since the indicator is quite common in the SD indicator systems of the member states.

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Appendix A.

Priority areas of a sustainable	Requirements for a sustainable mobility development (Cormier and Gilbert, 2005)	Priority areas of a sustainable transport development	Transport problems mentioned in strategic policy documents
Inter-generational justice	Reducing environmental impacts beneath the planetary boundaries determined by the maximum capacity of regeneration and substitution, respectively the carrying capacity	1. Climate change	Greenhouse gas emissions
		2. Energy consumption	Energy usage, energy mix, energy efficiency
	Decoupling, reduction of energy and resource consumption as well as traffic through increasing efficiency	3. Decoupling	Traffic growth, urban congestion, transport intensity, modal split
	Minimization of land consumption	4. Land use and fragmentation	Land use, fragmentation
	No shift of financial burdens to the future Polluter dependent charging of costs associated with the transport system	5. Financial sustainability	User fees, External Costs, Decaying infrastructure, Liabilities, Subsidies, fair competition between modes
Quality of life	Avoidance of health risks	6. Air quality	Emissions of air pollutants
		7. Noise	Noise
	Ensuring a safe environment for everyone	8. Traffic safety	Traffic accidents
Social cohesion	Fulfillment of basic needs and participation in social life for everyone Affordable prices Freedom of choice between different modes of transport	9. Guaranteeing mobility / access	Access, Accessibility, social exclusion, mobility of the poor and elderly, barrier-free access, mobility in rural areas
	Designing the transport system in a participatory process	10. Participation	-
International responsibility	Supporting a global sustainable development	11. International responsibility	-

Appendix B.

Country	Climate change	Energy use/ mix	Transport intensity	Modal split	Land use	Financial sustainability	Air quality	Noise	Traffic safety	Access	Sum
Austria	x			x	x	x	x	x		x	7
Belgium			x	x			x		x		4
Bulgaria		x		x		x			x		4
Croatia	x	x	x	x			x	x		x	7
Cyprus			x	x							2
Czech Republic			x	x	x						3
Denmark	x		x	x	x		x		x	x	7
Estonia	x	x		x			x		x	x	6
Finland				x				x		x	3
France	x		x	x			x				4
Germany			x	x							2
Greece			x	x	x		x		x		5
Hungary	x	x	x	x		x	x				6
Ireland	x	x		x			x			x	5
Italy	x		x	x			x	x		x	6
Latvia				x						x	2
Lithuania	x	x	x	x	x		x	x	x	x	9
Luxembourg	x			x	x		x		x		5
Malta	x			x						x	3
Netherlands				x			x	x	x		4
Poland	x	x	x	x	x		x				6
Portugal		x		x							2
Romania		x	x	x		x			x		5
Slovakia			x								1
Slovenia				x							1
Spain	x	x					x				3
Sweden		x	x	x					x	x	5
United Kingdom	x			x				x			3
Sum	14	11	15	26	7	4	15	7	10	11	120

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